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ABSTRACT

The premise of the Creative Technology Project, a collaboration by Autodesk, Inc., the School of Education at Oregon State University, and Novato Unified School District in the San Francisco Bay Area, was that children's cognitive abilities could be enhanced by having them develop, displace, transform, and interact with 2D and 3D computer-generated models. Subjects of the study were 23 elementary students between the ages of 8 and 11 who worked at either a computer workstation or a virtual reality/cyberspace system. Four cognitive ability tests were administered to the subjects: the Differential Aptitude Test, Minnesota Paper Form Board Test, Mental Rotation Test, and Torrance Test of Creative Thinking. Results of the project showed that spatially-related problem-solving abilities of children are influenced by training in visualization and mental manipulation of two-dimensional figures and displacement and transformation of mental images of three-dimensional objects. Further research regarding computer workstation graphic-based treatments and perceived realism and their relationship to problem solving should be undertaken. It is concluded that the technology known as virtual reality is highly promising and deserves extensive development as an instructional/training tool. (Author/ALF)

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The Creative Technologies Project

A Study of the Relationship Between Virtual Reality (Perceived Realism) and the Ability of Children to Create, Manipulate and Utilize Mental Images for Spatially Related Problem Solving

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Abstract

The Creative Technology Project was designed to see if certain technological innovations were capable of enhancing various cognitive abilities of children. The abilities under investigation were mental imagery, spatial relations, displacement and transformation, creativity and spatially related problem solving. The project's premise was that these cognitive abilities could be enhanced by having the children develop, displace, transform and interact with 2D and 3D computer-generated models.

Experiments were performed using 23 subjects between the ages of 8 and 11 who were enrolled in an elementary summer school program in Novato, California. Two different computer apparatuses were used for the experiments: computer workstations and a virtual reality/cyberspace system developed by Autodesk, Inc. of Sausalito, California. The workstation treatment incorporated three booklets to instruct the subjects on how to solve five different spatial relationship problems. The virtual reality/cyberspace treatment included two scripts to guide the subjects in solving two different spatial relationship problems.

Four cognitive ability tests were administered to the subjects. The dependent variable (i.e., spatially related problem solving) was measured with the Differential Aptitude Test. The three other measures (Minnesota Paper Form Board Test, Mental Rotation Test, and the Torrance Test of Creative Thinking) were used to determine any effects which mental imagery may have had on the subjects' abilities to mentally manipulate two-dimensional figures, displace and transform mental images, and creative thinking.

The Creative Technologies Project has shown that spatially related problem solving abilities of children are influenced by training in visualization and mental manipulation of two-dimensional figures and displacement and transformation of mental images of three-dimensional objects. Additionally, the treatments used in this study enhanced children's abilities to visualize and mentally manipulate two-dimensional figures, displace and transform mental images of three-dimensional objects, and solve spatially related problems. Further research regarding computer workstation graphic-based treatments and perceived realism and their relationship to problem solving should be undertaken. Virtual reality/cyberspace and the workstation treatments used in this study enhanced children's abilities to visualize and mentally manipulate two-dimensional figures, displacement and transformation of mental images of three-dimensional objects, and solving spatially related problems. The project has shown that the technology known as virtual reality is highly promising and deserves extensive development as an instructional/training tool.

The Creative Technologies Project

Introduction

When industry, higher education and public schools collaborate on projects involving emerging technologies, everyone can come out a winner. Such was the case when the high-tech firm of Autodesk, Inc., the School of Education at Oregon State University, and the Novato Unified School District in the San Francisco Bay Area collaborated on the Creative Technologies Project designed by this author.

Project Details

The Creative Technology Project was designed to see if specially designed virtual reality training was capable of enhancing certain cognitive abilities of children. The abilities under investigation were mental imagery, spatial relations, displacement and transformation, creativity and spatially related problem solving. The project's premise was that these cognitive abilities could be enhanced by having the children develop, displace, transform and interact with 2D and 3D computer-generated models.

Experiments were performed with 23 children between the ages of 8 and 11 who were enrolled in an elementary summer school program in Novato, California. Two different computer apparatuses were used for the experiments: computer workstations and a virtual reality/cyberspace system developed by Autodesk, Inc. of Sausalito, California. The workstation treatment incorporated three booklets to instruct the subjects on how to solve five different spatial relationship problems. The virtual reality/cyberspace treatment included two scripts to guide the subjects in solving two different spatial relationship problems.

Four cognitive ability tests were pre- and post-administered to the children. The dependent variable (i.e., spatially related problem solving) was measured with the Differential Aptitude Test. The three other measures (Minnesota Paper Form Board Test, Mental Rotation Test, and the Torrance Test of Creative Thinking)

After completing their drawings, the students would often look at each others drawings and discuss how they performed various drawing functions. They began to talk to each other in a new technical language:

"How did you make that arc curve down?"
"I just picked the third point below the second."

These children were beginning to understand and appreciate the power of developing drawings by using a computer. And as they completed more of their assigned projects, their skills improved. In fact, some of the children got together during their free time and used the graphic and text functions they had learned to develop a prototype school newspaper. Other students began developing very sophisticated graphic puzzles. When the puzzles were completed, they would use editing commands to take them apart. Once apart, they would re-assemble them in various rotations. There appeared to be no shortage of creativity with this group of children.

Training in Virtual Reality

The second group of students were trained in the use of this relatively new technology known as virtual reality or cyberspace. Virtual reality provides a new way of interacting with computers. In virtual reality, users interact with computer graphic models and data as though the models were virtually real. This human-computer interface provides the ability to virtually simulate, and interact with, any "reality" that can be imagined.

Humans experience reality through signals that the senses of vision (light waves), hearing (sound waves), touch (nerve impulses), taste (substances passing over receptor cells, taste buds in the mouth), and odor (nerve impulses in the nostrils) receive. These signals are responsible for the "reality" that our senses perceive and our minds create.

sensory world via a continuous feedback loop (Walser, 1990). The components which make up a typical virtual reality (VR) system include:

Visual Displays

Visual displays used in most VR systems are head-mounted or goggle-like in nature. That is, the displays are positioned directly in front of the user's eyes. The display is either head-mounted using a retaining device to maintain its position in front of the eyes, or a non-head mounted visual display which can be manually positioned in front of the eyes as needed. Virtual environment display devices allow graphic models to be perceived as "real" three-dimensional worlds. This perception is caused by the stimulation of the depth cues of motion parallax and binocular disparity (Merickel, 1991).

VPL Corporation of Redwood City, California has developed a head-mounted three-dimensional display device called EyePhones(tm). EyePhones are head-mounted stereoscopic displays that utilize wide angle lenses which allow a horizontal field of view of 80 degrees for one eye and 100 degrees for both eyes, and a vertical field of view from between 60 to 75 degrees. VPL offers two EyePhones models, the LX and the HRX. The HRX contains two 275 dpi LCD color displays which accept standard NTSC video signals. The LCD matrix of the LX EyePhones is 360 x 240 primary colored pixels, while the HRX offers a 720 x 480 matrix.

Fiber Optic Motion Sensors

Fiber optic motion sensors, ranging from a single glove for monitoring wrist, hand, and finger movements, to complete body suits which are covered with over 500 fiber optic sensors to detect "full" body movements, are used to sense motions and gestures. The most commonly used hand motion and gesture recognition device is the DataGlove produced by VPL Research, Inc. The DataGlove is a computer input glove that converts hand motion into computer readable form. Lightweight fiber optic sensors are mounted on a Lycra(tm) glove, and measure finger flexation.

pinnae filtering are also rendered by the Convolvotron. VPL Research, Inc. uses the Convolvotron to create what it calls the AudioSphere. The AudioSphere contains an integrated digital sound sampler that provides sound sources for use as user interface cues, improved object feedback, and other virtual reality applications.

Graphics Rendering

The graphic images which make up virtual worlds consist of surface rendered three-dimensional models. To perform this function, virtual reality systems must have rendering engines which are capable of rendering the virtual world models with each change of the user's position and orientation. This requires that specific rendering processing be dedicated to each of the two LCD monitors contained within the virtual system display device.

The VPL RB2 system accomplishes this task by using two dedicated Silicon Graphics workstations as rendering engines. The RB2 system can utilize any Silicon Graphics workstation, such as the SkyWriter, as well as other vendors' graphics workstation, in a single or dual configuration for enhanced performance. VPL's RB2 Model 2 system is capable of performing image rendering using a single Silicon Graphics 4D/310VGX workstation configuration.

The Autodesk, Inc. cyberspace (i.e., virtual reality) system, used for this project, requires two graphics boards in a PC-based system (one for each LCD monitor contained in the virtual system display). Currently, the cyberspace system uses two Matrox graphics boards which are built around the Texas Instrument 34010 signal processing chips and custom gate arrays. The Matrox boards are attached to a passive AT backplane which supports a 20Mhz Intel 80386 processor board and a number of serial, Ethernet, and disk controller cards. The matrox boards generate the three-dimensional perspective images which are then converted via NTSC converter into standard video signals. The NTSC signals are then sent to the two LCD displays inside the headset, thus producing a stereoscopic display.

During the second experiment, most students were traveling in virtual space with little or no difficulty. The student's gestures were fluid and, therefore, so was their traveling in virtual space. The children began to relax and walk around more, even though walking movement is restricted by the cables that attach the DataGlove and head-mounted display to the tracking interface equipment. Students began to turn or walk around in order to track and find various items. The children appeared to have no preconceived notions or reservations about "traveling inside a computer." In summary, these children had become quite proficient with this cutting-edge technology in a very short time.

Project Results

The results of the study indicated that a relationship between perceived realism and the ability of children to create, manipulate and utilize mental images in solving spatially related problems is unverified at this time. The results also indicated that displacement and transformation and visualizing and mentally manipulating two-dimensional objects were significantly related to spatially related problem solving abilities of children ($R = .68$, $F = 8.05$, ndf = 1,20, $p = .00$). Although creative thinking was found not to be significantly related to spatially related problem solving abilities of children, the relationship between spatially related problem solving and creative thinking is still uncertain.

The results also indicated that both groups made significant gains in spatially related problem solving ($F = 7.35$, ndf = 1,21, $p = .013$), visualization ($F = 5.21$, ndf = 1,21, $p = .033$) and displacement and transformation ($F = 23.24$, ndf = 1,21, $p = .000$), however there were no significant gains by either treatment group for creative thinking ($F = 1.75$, ndf = 1,21, $p = .201$). Additionally, there was no apparent difference between treatments for visualization ($F = 2.40$, ndf = 1,21, $p = .137$) and creative thinking ($F = 1.67$, ndf = 1,21, may not occur. The Creative Technologies Project was an attempt to test the outcomes of using new technologies before naive and inappropriate educational methodologies are adopted for classroom use. The project was specifically designed to provide answers to the question: can the development, displacement and transformation of, and interaction with, 2D and/or 3D computer graphics enhance a child's ability to create, manipulate and utilize mental images; their spatial and visual abilities; displacement and transformation abilities; creative thinking ability, and spatially related problem-solving abilities?"

This project showed that additional research on particular interactions between 2D and 3D computer graphics and virtual reality, and various cognitive abilities of children, is warranted. The research has also shown that the technology known as virtual reality is highly promising and deserves extensive development as an instructional and training tool. But equally important, the cooperative efforts required by Autodesk, Inc., the School of Education at Oregon State University and the Novato Unified School District proved beneficial to all involved. Industry was provided feedback on their technology in action. Education is allowed to test innovative approaches to instruction in a controlled setting and use state-of-the-art equipment. And children, they get to fly!